

Study On Hexavalent Chromium Content (Cr6+) In Raw Water Source Of Krueng Meurebo River, West Aceh

^{1,2}Nanda Qoriansas, ²Rizki Andriani, ^{3,2}Ira Sahwadi, ¹Riski Rahmayati, ²Ardi Ficri Harahap

¹UPTD Laboratorium Kesehatan Daerah Aceh Barat, Indonesia

²STIKes Medika Seramoe Barat, Indonesia

³Dinas Kesehatan Nagan Raya, Indonesia

Corresponding author: Rizki Andriani, e-mail: rizkiandriani@stikesmsb.ac.id

Abstract

Illegal industrial and mining activities in the upstream coastal area of West Aceh are at risk as a source of heavy metal pollution for raw water sources of local communities. One of them is chromium VI (Cr6+) heavy metal which is harmful because it cannot decompose in the body and become a poison that causes health effects on humans as well as aquatic organisms. The Krueng Meurebo River, as the main source of raw water that meets the clean water needs of the local community, is now threatened by this potential contamination. Objective: This study aims to analyze Cr6+ exposure in raw water source of the Krueng Meurebo River, West Aceh. Water sampling was carried out at 3 points along the Krueng Meurebo River, namely the waters of the Tuha Mosque, Ranto Panyang Barat and Runding. Each sample was analyzed using a tablet reagent, followed by further examination using the ZE-200 photometer to determine the content of heavy metal Cr6+ at each sampling points. The results of the analysis of Cr6+ heavy metal exposure in the waters of the Tuha Mosque were 0.10 mg/l, while the results in Ranto Panyang and Runding were 0.08 mg/l. This result is above the maximum limit of Cr6+ content allowed in water as many as 0.01 mg/l. The Krueng Meurebo River stream shows significant levels of exposure to heavy metals Cr6+, posing a serious threat to the health of communities who rely on the river's raw water source. With these conditions, immediate action is needed in the form of an Environmental Health Risk Analysis (ARKL) to further assess the impact of Cr6+ exposure on human health. Measures to prevent and handle industrial waste need to be optimized immediately to protect the environment and public health in the West Aceh region.

Keywords: Cr6+; Hexavalent Chromium; River; Water; West Aceh

Introduction

Indonesia, with the fifth largest water potential in the world (Dewan Sumber Daya Air Nasional, 2019), is facing a pressing challenge in maintaining water quality due to widespread pollution. Kementerian Lingkungan Hidup dan Kehutanan (2022) reported that in 2020, a staggering 59% of rivers in Indonesia were heavily polluted. Only nine rivers met quality standards in 2022, a mere 8.2% out of 110 rivers identified. The urgency of this issue is underscored by the fact that the cleanliness of the aquatic environment is highly determined by waste disposal, be it in the form of organic, inorganic, or suspended waste (Peraturan Menteri Lingkungan Hidup Dan Kehutanan Republik Indonesia Nomor 5 Tahun, 2021).

Heavy metals are a type of inorganic waste classified as hazardous to the environment and at risk of

becoming acute or chronic poison when drinking. One of the heavy metals of concern as an environmental contaminant is chromium (Cr) in water, which is the route of exposure to the metal (Tchounwou et al., 2012). Cr is an element in the soil formed by natural processes in groundwater, erosion, and rock-water interaction (Kazakis et al., 2017; Moraetis et al., 2012). Human activities such as mining and industrial waste disposal in water can increase the concentration of Cr (Georgaki et al., 2023) to chromium VI or hexavalent type (Cr 6+). Cr 6+ cannot be degraded in the body, so it accumulates and harms aquatic organisms and humans (Nair & Kurian, 2018).

West Aceh Regency is located in the waters of the Southwest of Aceh Province. Clean water services in West Aceh Regency are managed by PDAM Tirta Meulaboh with a piping system (Qanun Kab. Aceh Barat No. 4 Tahun 2021 Perusahaan Perusahaan Umum Daerah Air Minum Tirta Meulaboh) serving four sub-districts (Johan Pahlawan, Meureubo, Kaway XVI, and Arongan Lambalek). The source of raw water comes from the Krueng Meureubo River, which has an average discharge of 100 m³/second and is available all year round. The Krueng Meureubo River is one of the major rivers. It is a national strategic river that passes through the West Aceh Regency area, where it flows along 188 km and into the Indian Ocean (Jumhasla Putra et al., 2018). Several industrial units are located in the waters of West Aceh, namely the coal processing industry, the steam power plant industry (PLTU), the gold mining industry, ship waste, and household waste. Uncontrolled waste disposal risks polluting the waters of West Aceh, which is the center of food sources and livelihoods of the community.

Cr6+ is the most toxic, highly soluble, and carcinogenic form of chromium (Mishra & Bharagava, 2016) and can be exposed to the human body through water, food, or air. Case studies have shown that continuous exposure to Cr6+, even at low levels, can have detrimental effects on the body (Zhang et al., 2014). WHO (2008) has linked Cr6+ to stomach cancer, lung cancer, and Hodgkin's disease, classifying it as a highly carcinogenic substance (Saha et al., 2011). A methodological study conducted by Georgaki et al. (Georgaki et al., 2023) stated that Cr6+ circulating through water is a major contributor to the occurrence of cancer in humans and is a significant public health problem (Georgaki et al., 2023). These findings should raise serious concerns about the public health risks associated with the use of the raw water source of the Krueng Meurebo River, which is exposed to Cr6+.

Several studies related to heavy metals were carried out in the waters of West Aceh. Munandar & Alamsyah (2016) mentioned that mercury heavy metals in Krueng Meureubo, West Aceh, passed the quality standard limit. Edwarsyah & Iqbal (2017) and Warni et al. (2017) also mentioned that there are heavy metals content of cadmium, iron, lead, copper, manganese, and zinc in West Aceh waters that exceed the quality standard limit. However, until now, no one has researched anything related to the Cr6+ heavy metal. When viewed from the level of toxicity in heavy metals Cr6+, in addition to being attractive, it is essential to research. It must also be a particular concern, especially in the waters of West Aceh. This is undoubtedly reinforcement, so this research is carried out to determine whether the waters in West Aceh experience the

same thing so that risk management can be planned for the future. Dari penjelasan tersebut diatas, maka penelitian ini akan menganalisis pajanan Cr6+ pada sumber air baku Sungai Krueng Meurebo Kabupaten Aceh Barat. From the explanation above, this study will analyze the exposure of Cr6+ in the raw water source of the Krueng Meurebo River, West Aceh Regency.

Methods

This study employs a quantitative approach with an quasi experimental design to evaluate the impact of controlled interventions on water quality issues, activity patterns, anthropometry, and population demographics. The research focuses on analyzing Cr6+ exposure in raw water sources from the Krueng Meurebo River, West Aceh Regency, Aceh Province. The population in this study is a river flow, a canal of the Krueng Meurebo River. The primary samples taken in this study were water samples in three sub-districts (Johan Pahlawan, Meurebo, and Kaway XVI) that were passed by the Krueng Meurebo River so that a total of three water samples amounted to three. Water quality and Cr6+ exposure data were obtained from chemical examination and analysis of the water of the Krueng Meurebo River, West Aceh. River water samples are taken directly using glass bottle containers numbered on the sample label.

Furthermore, water samples transported to the West Aceh Regional Health Laboratory to be checked for Cr6+ levels using the photometry method using a tablet reagent, which will then be examined through the ZE200 photometer. In addition to measuring the content of Cr6+, river water measurement also measures other physical parameters, including color, turbidity, and odor, as well as chemical parameters, including pH and Total Dissolved Solid (TDS). The results of the tested water samples, namely Cr6+, were then analyzed with quality standard requirements according to the Minister of Health Regulation No. 492 of 2010 concerning Drinking Water Quality Requirements.

Results

This study was conducted to measure exposure to Cr6+ heavy metals in waters and examine physical parameters in the form of pH and Total Dissolved Solids (TDS) in several locations, namely Tuha, Ranto Panyang, and Runding Mosques. The measurement results showed that the Cr6+ levels at all three locations exceeded the maximum allowable limit according to water quality standards. In the waters of the Tuha Mosque, the concentration of Cr6+ was recorded at 0.10 mg/l, far above the set safe limit of 0.01 mg/l. Meanwhile, the results of Cr6+ measurements in Ranto Panyang and Runding waters showed a value of 0.08 mg/l, exceeding the permissible threshold.

In addition to the Cr6+ content, pH and TDS parameters are also measured in the water quality analysis. The pH measurement results in the waters of the Tuha Mosque are 8.11, indicating that the water is alkaline. The TDS measurement at this location was recorded at 61.9 mg/l, which is still within the allowable range for water. In the waters of Ranto Panyang and Runding, the pH measured was 8.16, which also showed

alkaline properties, with a TDS value of 77.5 mg/l, slightly higher than the waters of the Tuha Mosque but still within reasonable limits. Overall, the pH and TDS at all three locations are within the normal range. The results of measuring Cr6+ levels by photometry on samples can be observed in Table 1

Table 1. Distribution of body mass index measurements and food consumption

Sampling Point	Cr6+ Heavy Metal Content (mg/l)	Note
Mesjid Tuha Point	0,10	does not meet the standards
Ranto Panyang Point	0,08	does not meet the standards
Runding Point	0,08	does not meet the standards

(data primer, 2024)

*Desc: Meet the standard if < 0.05 mg/l based on Permenkes No. 492 Year 2010 concerning Drinking Water Quality Requirements.

Discussion

The results showed that the concentration of Cr6+ heavy metals in the Tuha, Ranto Panyang, and Runding Mosques waters exceeded the maximum permissible limit, which was 0.01 mg/l. The concentration of Cr6+ in the Tuha Mosque was recorded at 0.10 mg/l, while in Ranto Panyang and Unding, it was recorded at 0.08 mg/l. These values are well above the water quality standards set by some environmental regulations, which indicate severe pollution in these waters. Hexavalent chromium (Cr6+) is known to be one of the most dangerous forms of chromium, as it is toxic and carcinogenic. Based on the ATSDR report (2012), long-term exposure to Cr6+ can cause various serious health problems, such as lung cancer, kidney, and liver damage, as well as skin and respiratory tract irritation. In aquatic ecosystems, Cr6+ can accumulate and have an impact on aquatic biota as well as humans who consume polluted aquatic products. According to Costa & Klein (2006), chromium can accumulate in aquatic organisms and enter the food chain, leading to broader exposure in the population.

The primary source of Cr6+ pollution in water often comes from industrial waste, such as metal manufacturing, textile production, and leather tanning processes. This waste, if not appropriately treated, can significantly contaminate water bodies. Uncontrolled discharge into the aquatic environment can lead to increased levels of heavy metals, negatively impacting water quality and the health of the surrounding environment. Stricter industrial waste control and environmentally friendly waste treatment technology are urgently needed to prevent further pollution.

In addition to Cr6+ concentration, the results of this study also measured other parameters, namely pH and Total Dissolved Solids (TDS). The pH value at the Tuha Mosque location was recorded at 8.11; in Ranto Panyang and Unding, it reached 8.16, indicating that the water is alkaline. Water with alkaline properties may not directly endanger human health, but it can impact aquatic ecosystems. A high pH can increase the toxicity of some heavy metals, including Cr6+, by making them more soluble in water and available for absorption by organisms. This condition increases the risk of heavy metal poisoning for aquatic life and humans who are exposed to water or food consumption from these waters.

The TDS parameter at the Tuha Mosque location is 61.9 mg/l, while in Ranto Panyang and Runding, it is 77.5 mg/l. TDS indicates the amount of dissolved substances in water, such as salts, minerals, and heavy metals. The measured TDS value in this study is still within the safe limit, below 500 mg/l as recommended by the WHO for drinking water. However, despite the relatively low TDS value, the presence of high levels of Cr6+ remains a significant concern, as this heavy metal can cause health impacts even in small amounts.

Overall, although the pH and TDS values in the waters of the Tuha, Ranto Panyang, and Anding Mosques are still within normal limits, the high concentration of Cr6+ above the permissible threshold indicates that pollution requires serious attention. Managing and supervising pollution sources is essential to minimize environmental and health impacts. According to Rai et al. (2019), heavy metals such as Cr6+ can harm ecosystems, so immediate action is needed to reduce such pollution.

Cr6+ exposure not only impacts water quality but also has the potential to pose health risks to people who use water from these sources for daily needs, such as drinking water and other domestic activities. In addition, aquatic ecosystems are also at risk of damage due to the accumulation of heavy metals in aquatic organisms. Therefore, strict supervision of industrial waste and implementing water pollution mitigation strategies are needed to protect public health and the environment around the research area.

Conclusion

This study revealed that laboratory tests indicated Cr6+ concentrations in the waters of Tuha, Ranto Panyang, and Runding Mosques exceeded the maximum allowable limit of 0.01 mg/L, as stipulated in Minister of Health Regulation No. 492 of 2010 concerning Drinking Water Quality Requirements. The measured Cr6+ levels were found to be 0.10 mg/L (Mesjid Tuha), 0.8 mg/L (Ranto Panyang) and 0.8 mg/L (Runding), confirming significant contamination. These findings highlight the urgent need for mitigation measures to reduce Cr6+ levels and prevent further pollution. Elevated Cr6+ levels pose serious health risks to communities relying on these water sources for daily use and can lead to the deterioration of the aquatic ecosystem.

Acknowledgment

The project was fully supported financially by researcher as a part from UPTD Laboratorium Kesehatan Daerah Aceh Barat and STIKes Medika Seramoe Barat who has helped the way this research

Author Contribution and Competing Interest

NQ Conceptualization, Formal Analysis, Methodology, Validation, Visualization, Writing – Original Draft, Review & Editing; RA Investigation, Methodology, Validation, and Writing – Original Draft, Review & Editing; IS: Methodology, Validation, and Writing – Original Draft, Review & Editing; RR Resources, Investigation, and Writing –Review & Editing; SH Formal Analysis, Validation, Writing – Review & Editing; AFH Resources, Supervision, and Writing –Review & Editing

References

- Agency for Toxic Substances and Disease Registry (ATSDR). (2012). Toxicological Profile for Chromium. U.S. Department of Health and Human Services, Public Health Service.
- Costa, M., & Klein, C. B. (2006). Toxicity and Carcinogenicity of Chromium Compounds in Humans. *Critical Reviews in Toxicology*, 36(2), 155–163.
- Dewan Sumber Daya Air Nasional. (2019). Rekomendasi Isu Strategis Ketahanan Air. <https://www.dsda.go.id/mdocs-posts/2019-rekomendasi-isu-strategis-ketahanan-air>
- Edwarsyah, & Iqbal, M. (2017). Kuantitas Kandungan Logam Berat dan Minyak Solar di Estuaria Krueng Cangkoi, Meulaboh, Kabupaten Aceh Barat. *Acta Aquatica: Aquatic Sciences Journal*, 4(2), 83–87. <https://doi.org/10.29103/AA.V4I2.307>
- Georgaki, M. N., Charalambous, M., Kazakis, N., Talias, M. A., Georgakis, C., Papamitsou, T., & Mytigliaki, C. (2023). Chromium in Water and Carcinogenic Human Health Risk. *Environments*, 10(2), 33. <https://doi.org/10.3390/ENVIRONMENTS10020033>
- Goyer, R. A., & Clarkson, T. W. (2001). Toxic Effects of Metals. In Klaassen, C. D. (Ed.), *Casarett and Doull's Toxicology: The Basic Science of Poisons* (6th ed.). McGraw-Hill.
- Jumhasla Putra, A. Z., Masimin, M., & Fatimah, E. (2018). Kajian Kerugian Risiko Banjir Pada Sungai Krueng Meureubo. *Jurnal Arsip Rekayasa Sipil Dan Perencanaan*, 1(2), 172–182. <https://doi.org/10.24815/JARSP.V1I2.10966>
- Kazakis, N., Kantiranis, N., Kalaitzidou, K., Kaprara, M., Mitrakas, M., Frei, R., Vargemezis, G., Tsourlos, P., Zouboulis, A., & Filippidis, A. (2017). Origin of hexavalent chromium in groundwater: The example of Sarigkiol Basin, Northern Greece. *Science of The Total Environment*, 593–594, 552–566. <https://doi.org/10.1016/J.SCITOTENV.2017.03.128>
- Kementerian Lingkungan Hidup dan Kehutanan. (2022). Status Lingkungan Hidup Indonesia 2022.
- Mishra, S., & Bharagava, R. N. (2016). Toxic and genotoxic effects of hexavalent chromium in environment and its bioremediation strategies. *Journal of Environmental Science and Health, Part C*, 34(1), 1–32. <https://doi.org/10.1080/10590501.2015.1096883>
- Moraetis, D., Nikolaidis, N. P., Karatzas, G. P., Dokou, Z., Kalogerakis, N., Winkel, L. H. E., & Palaiogianni-Bellou, A. (2012). Origin and mobility of hexavalent chromium in North-Eastern Attica, Greece. *Applied Geochemistry*, 27(6), 1170–1178. <https://doi.org/10.1016/J.APGEOCHEM.2012.03.005>
- Munandar, & Alamsyah, A. (2016). Kajian Kandungan Logam Berat Merkuri (Hg) Pada Kerang Air Tawar (*Anodonta* sp) Di Kawasan Hilir Sub DAS Krueng Meureubo, Aceh Barat. *Jurnal Perikanan Tropis*, 3(1). <https://doi.org/10.35308/JPT.V3I1.32>
- Nair, D. S., & Kurian, M. (2018). Chromium-zinc ferrite nanocomposites for the catalytic abatement of toxic environmental pollutants under ambient conditions. *Journal of Hazardous Materials*, 344, 925–941. <https://doi.org/10.1016/J.JHAZMAT.2017.11.045>
- Peraturan Menteri Lingkungan Hidup Dan Kehutanan Republik Indonesia Nomor 5 Tahun 2021, Menteri Lingkungan Hidup dan Kehutanan Republik Indonesia. (2021). https://jdih.menlhk.go.id/new/uploads/files/2021pmlhk027_menlhk_12312021144624.pdf
- Qanun Kab. Aceh Barat No. 4 Tahun 2021 Perusahaan Perusahaan Umum Daerah Air Minum Tirta Meulaboh. Retrieved March 29, 2024, from <https://peraturan.bpk.go.id/Details/239942/qanun-kab-aceh-barat-no-4-tahun-2021>
- Rai, P. K., Lee, S. S., Zhang, M., Tsang, Y. F., & Kim, K. H. (2019). Heavy Metals in Food Crops: Health Risks, Fate, Mechanisms, and Management. *Environment International*, 125, 365–385.
- Saha, R., Nandi, R., & Saha, B. (2011). Sources and toxicity of hexavalent chromium. *Journal of Coordination Chemistry*, 64(10), 1782–1806. <https://doi.org/10.1080/00958972.2011.583646>
- Tchobanoglous, G., Burton, F. L., & Stensel, H. D. (2003). *Wastewater Engineering: Treatment and Reuse* (4th ed.). McGraw-Hill.
- Tchounwou, P. B., Yedjou, C. G., Patlolla, A. K., & Sutton, D. J. (2012). Heavy Metals Toxicity and the Environment. *EXS*, 101, 133. https://doi.org/10.1007/978-3-7643-8340-4_6
- Warni, D., Karina, S., & Nurfadillah, N. (2017). Analisis Logam Pb, Mn, Cu dan Cd Pada Sedimen di Pelabuhan Jetty Meulaboh, Aceh Barat. *Jurnal Ilmiah Mahasiswa Kelautan Perikanan Unsyiah*, 2(2),

246–253. <https://jim.usk.ac.id/fkp/article/view/4862>

WHO. (2017). Total Dissolved Solids in Drinking-water. Guidelines for Drinking-water Quality, 4th Edition. World Health Organization.

Zhang, R., Xiang, Y., Ran, Q., Deng, X., Xiao, Y., Xiang, L., & Li, Z. (2014). Involvement of Calcium, Reactive Oxygen Species, and ATP in Hexavalent Chromium-Induced Damage in Red Blood Cells. *Cellular Physiology and Biochemistry*, 34(5), 1780–1791. <https://doi.org/10.1159/000366378>